Update on Optimal Use of AIRS Retrievals in Analyses for Short-Term Weather Forecasts

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Goals

- Improve short-term numerical prediction of high impact weather events such as severe thunderstorms and flash floods
- Ability of the satellite to obtain data over the Gulf of Mexico promises to improve forecasts of air mass modification and return flow from the Gulf

Two Parts of Project

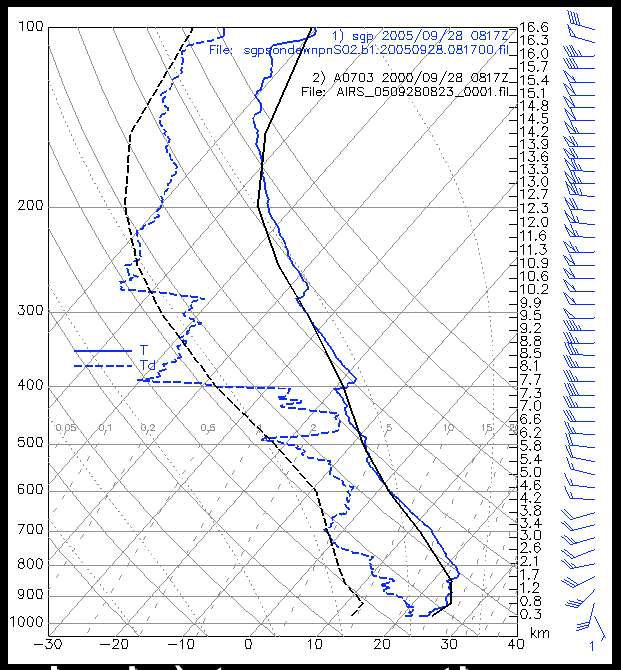
- Learn about the implicit smoothing of AIRS along with the bias and standard error
- Test impact of AIRS on the analysis and forecast

Examination of the Data

- Use retrieved soundings from DAAC
- Require some knowledge of the error associated with the data in order to use it properly in data assimilation
- Need to compute statistics on the data in order to best uses AIRS profiles

Comparison Soundings

- AIRS retrievals reported as point obs
- Due to nature of radiation measurements on which they are based, values are representative of layer averages
- Smooth validation sounding data before comparing with AIRS in order to find the filter parameter that best matches the AIRS data



- Use exponential function (as in Barnes Analysis) to smooth sounding in the vertical (1-D):

$$w_m = \exp[-r_m^2/k^2]$$

- r_m pressure difference between m^{th} observation and AIRS point (units: mb)
- k is the filter shape parameter (units: mb)
- Comparison soundings interpolated to 1 mb increments to be evenly spaced

- Two Sources of Comparison Data
  - ARM Southern Great Plains (SGP) site at Lamont, OK – land

    August 20, 2005 – April 19, 2006
  - ARM Tropical Western Pacific (TWP) site on Nauru Island – ocean

    September 16, 2005 – April 17, 2006
- 70 km limit for collocation
- Not rigorous validation, but a sample dataset chosen to get an estimate of statistics to be used for data assimilation

QC Flags

- QualTempProfileTop (above 200 mb)
- QualTempProfileMid (3 km above sfc-200 mb)
- QualTempProfileBot (sfc-3 km)
- QualSurf
- Flags have values between 0-2 with 0 being highest quality and 2 being do not use

Value	Letter
0	G
1	Q
2	B

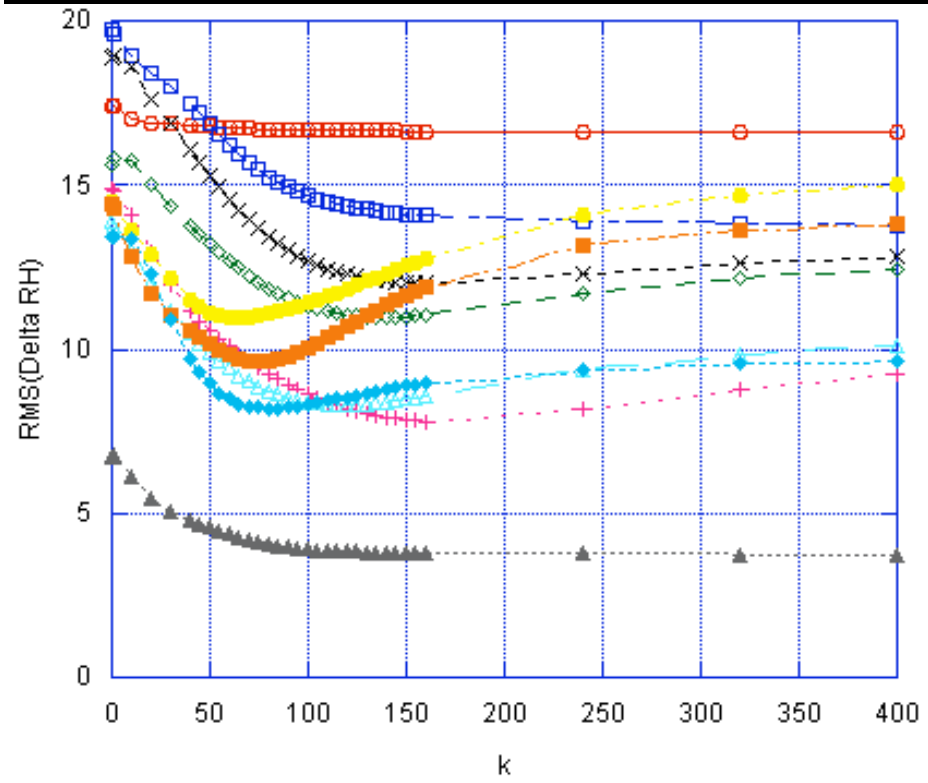
Site/QC Flag	# of Soundings
SGP GGGQ	52
SGP GGQQ	123
SGP GBBB	79
SGP BBBB	37
TWP GGGG	31
TWP GGGQ	38
TWP GGGB	60
TWP GGQB	37
TWP GBBB	55

(Top, Mid, Bot, Sfc)

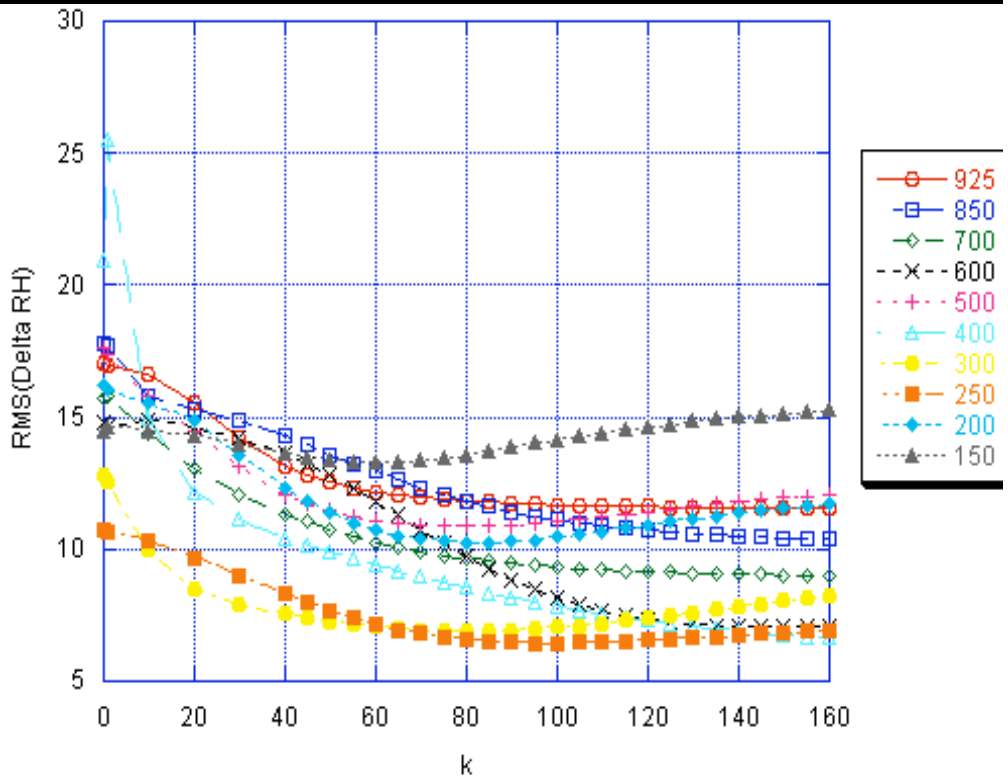
Bias Adjustment

- Bias calculated for each site, quality control flag, and pressure level
- Removed before computing statistics

Relative Humidity - GGGQ



SGP



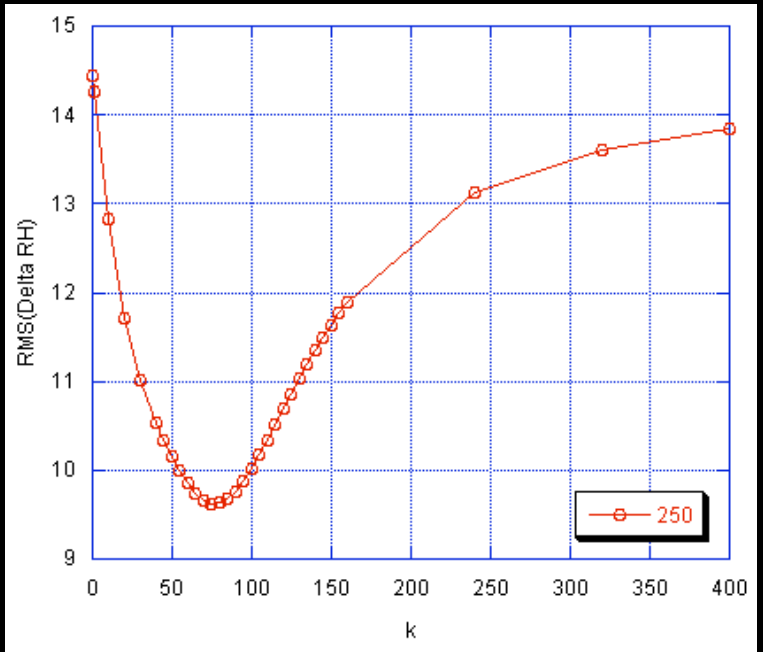
TWP

$w_m = \exp[-r_m^2/k^2]$

% of Maximum Reduction

- Seeking value of k filter parameter that is near minimum for a given pressure level but does not overly smooth data.
- Define new variable characterizing the reduction in difference compared to the maximum difference found

% red = [(reduction from max)/(max-min))]*100



k (mb) Values

SGP RH:

Pressure	k
925,300-200	50
400,150	85
850-500	120

TWP RH:

Pressure	k
925, 300-150	50
500,400	80
850-600	120

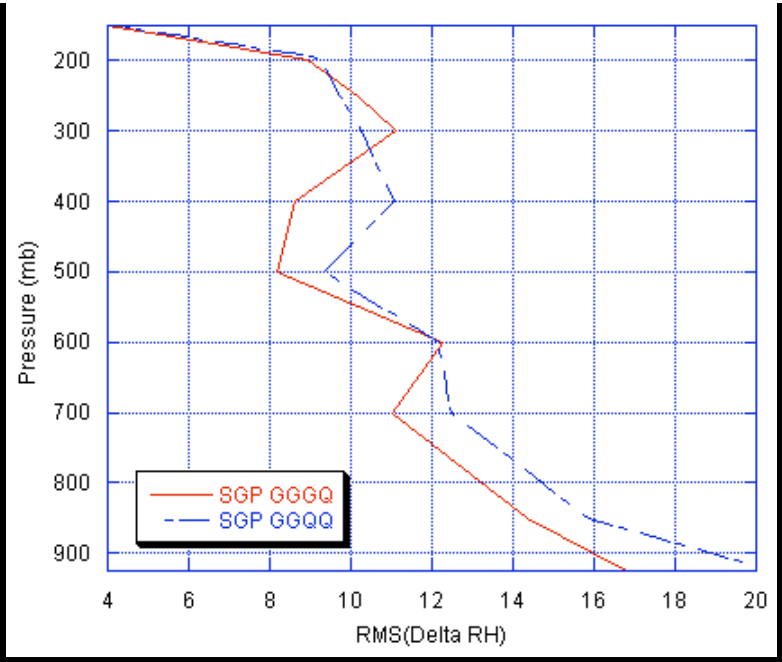
SGP T:

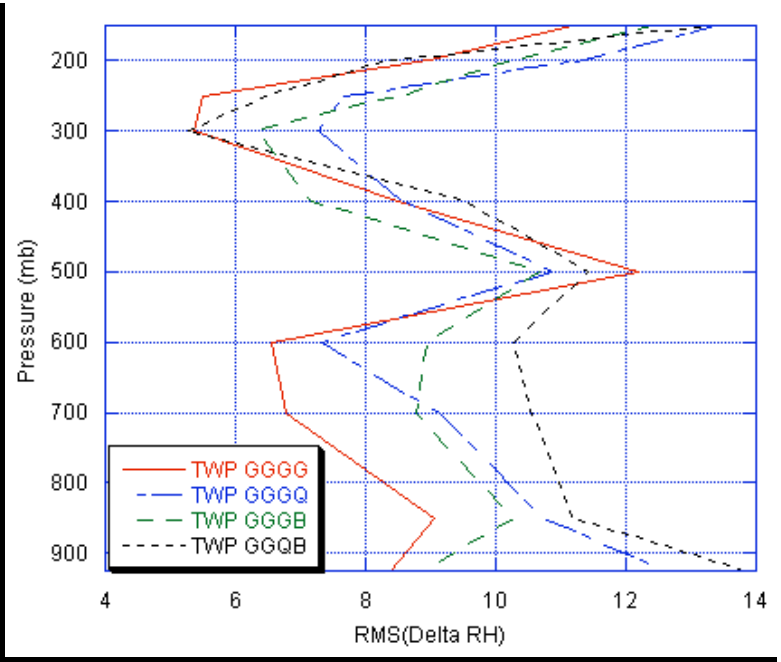
Pressure	k
925-600	70
500-150	40

TWP T:

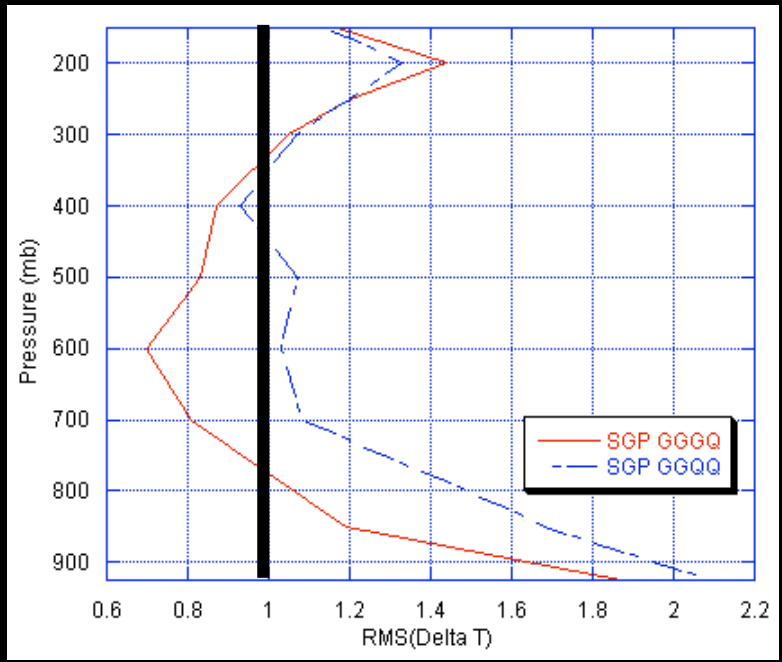
Pressure	k
925-500	40
400-150	20

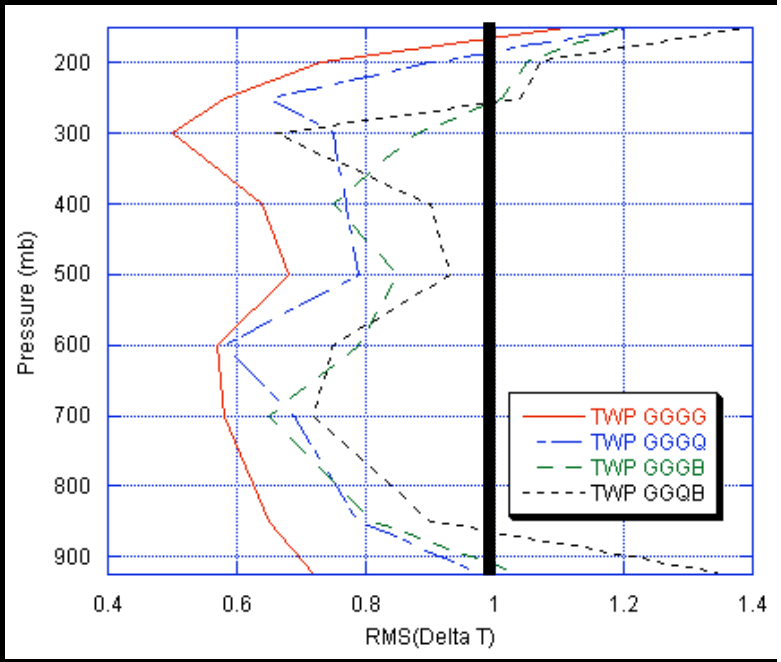
RMS RH





RMS T





SGP

TWP

QC Flag: Top, Mid, Bot, Sfc

Summary of Results for Validation

- Found a value of filter parameter, k, that minimized error
- Satellite data fit smoothed profiles better
- TWP-AIRS Ocean soundings agree better than SGP-AIRS Land

Impact of AIRS on Analysis and Forecast

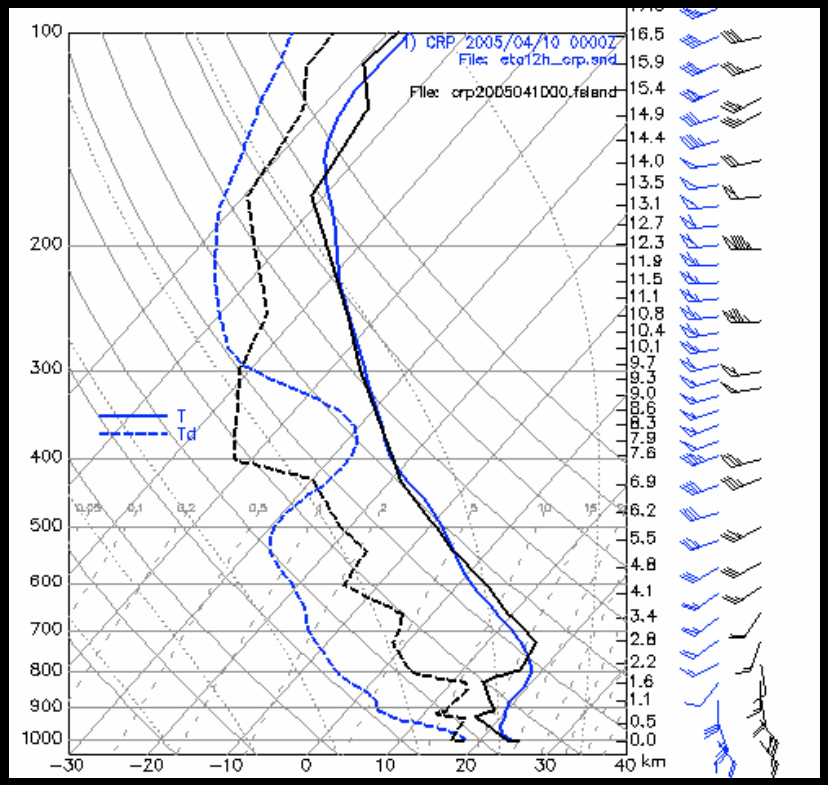
- First look at impact on initial analyses
- Want to know if addition of AIRS profiles over the ocean improve a high resolution forecast
  - Impact on humidity analysis
  - Impact on thunderstorm forecast
- Use ARPS model

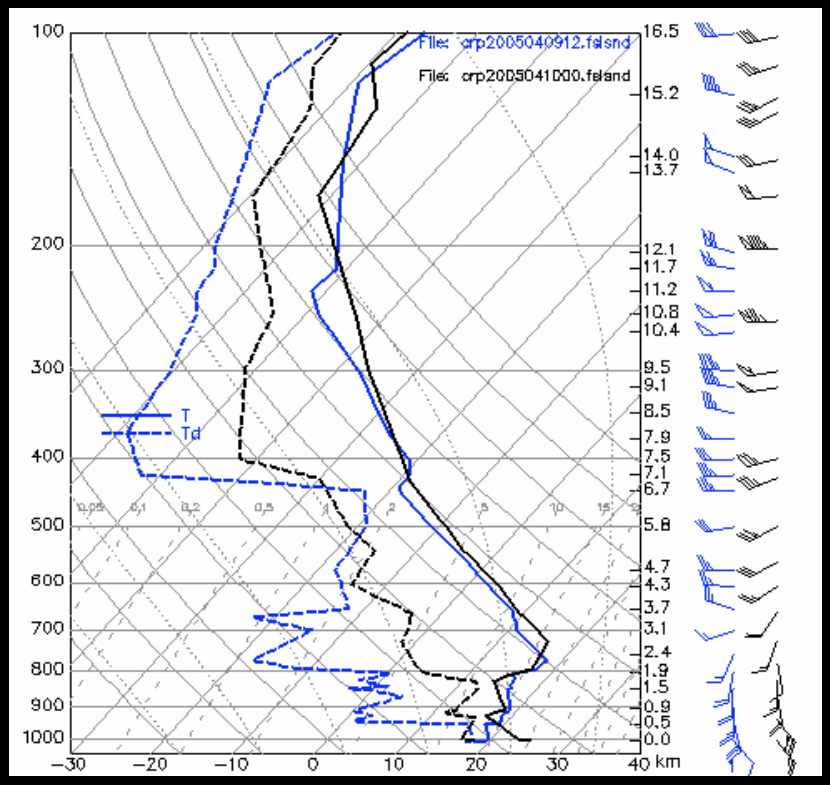
ADAS

- Use ARPS Data Analysis System (ADAS) to assimilate soundings into ARPS
- ADAS is a Bratseth successive correction statistical analysis that converges to optimal interpolation.
- Flexible system of ingesting data having varying sources and observation densities.
- Error characteristics of the data can be specified by each source and by height above ground level.
- Includes complex cloud analysis procedure that integrates cloud information from surface stations, visible and IR satellite data, and radar reflectivity.

Case: April 9, 2005

- The NAM (Eta) model under predicted moisture return along Gulf coast of Texas on the day preceding an outbreak of severe weather in northeast Texas and eastern Oklahoma



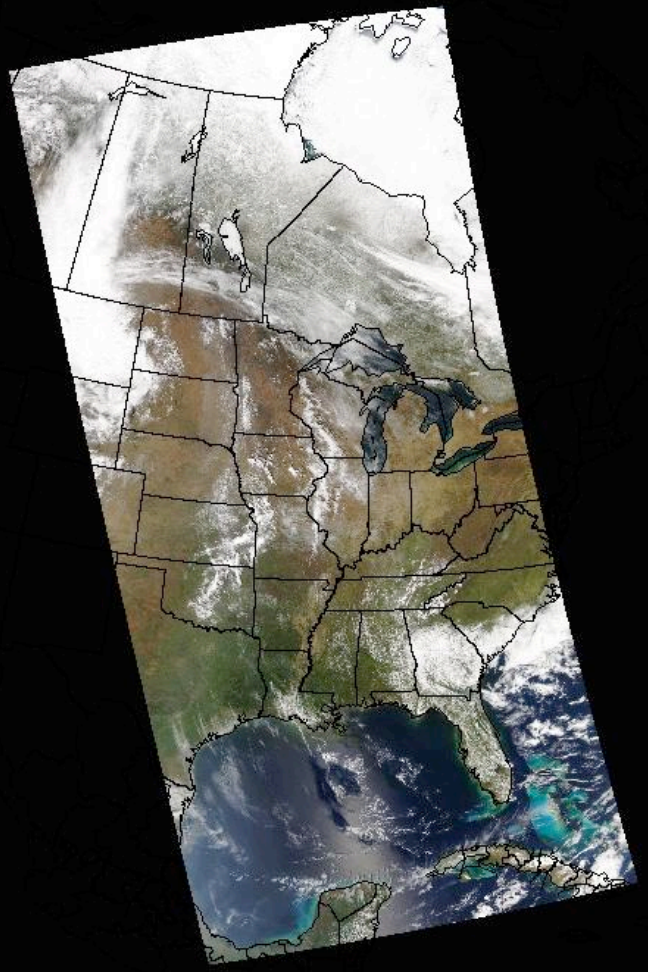


Left: CRP rawinsonde & NAM sounding 00 UTC April 10, 2005. Right: CRP 12 UTC April 9, 2005 and CRP 00 UTC April 10, 2005.

- Used AIRS soundings over the ocean
- Clear overpass, very little cloud cover

Top	Bot	Mid	Sfc	# of Soundings
G	G	G	G	182
G	G	G	Q	113
G	G	G	B	131
G	G	Q	Q	101
G	G	Q	B	37
G	B	B	B	126
B	B	B	B	4

Aqua MODIS
Composite Image
19Z 09 April 2005



- Initialization
  - Aqua passed over region around 19 UTC on April 9, 19 UTC used as initialization time of ARPS model
  - Archived NAM forecasts with 40-km resolution used as background field
- Other Sources
  - Surface Aviation Observations (METAR)
  - Buoy
- Model Resolution
  - 12 km horizontal resolution for ADAS analyses and boundary conditions, 3 km resolution for forecasts
  - 350 m average vertical resolution

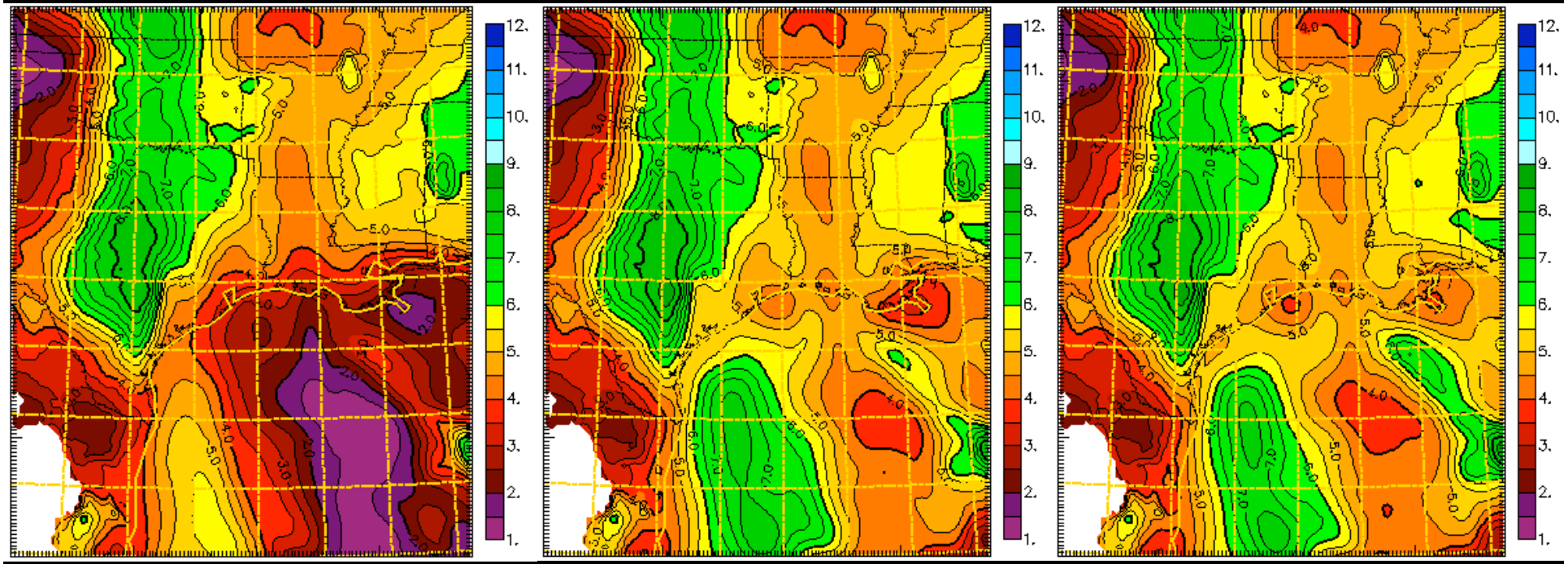
ADAS Analyses

Name	AIRS Ocean	Bias Correction	Updated Error Information	Background Smoothing
CTRL				
28V4.0 N	X			
28V4.0 BE	X	X	X	
28V4.0 BESO	X	X	X	X

Name Key

N: No Modification
B: Bias Correction
E: Updated Error Information
S: Smoothing of Background
O: Ocean

850 mb Specific Humidity 19Z

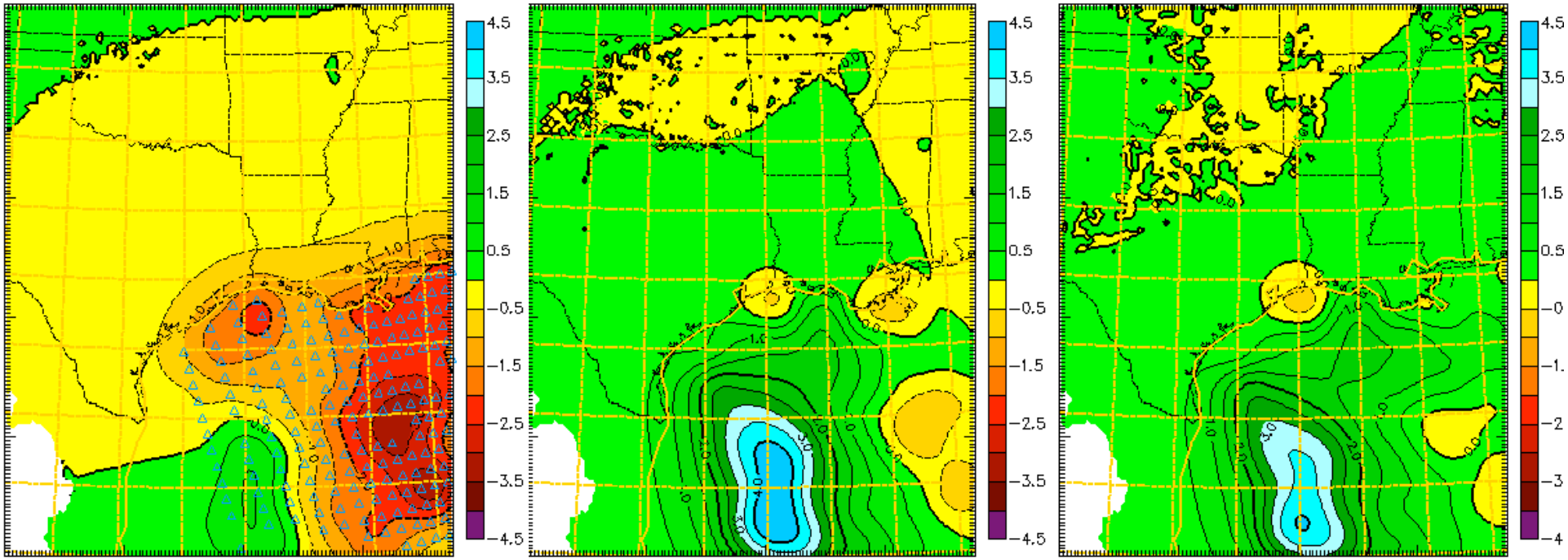


28V4.0 N
No Modification

28V4.0 BE
Bias Removed

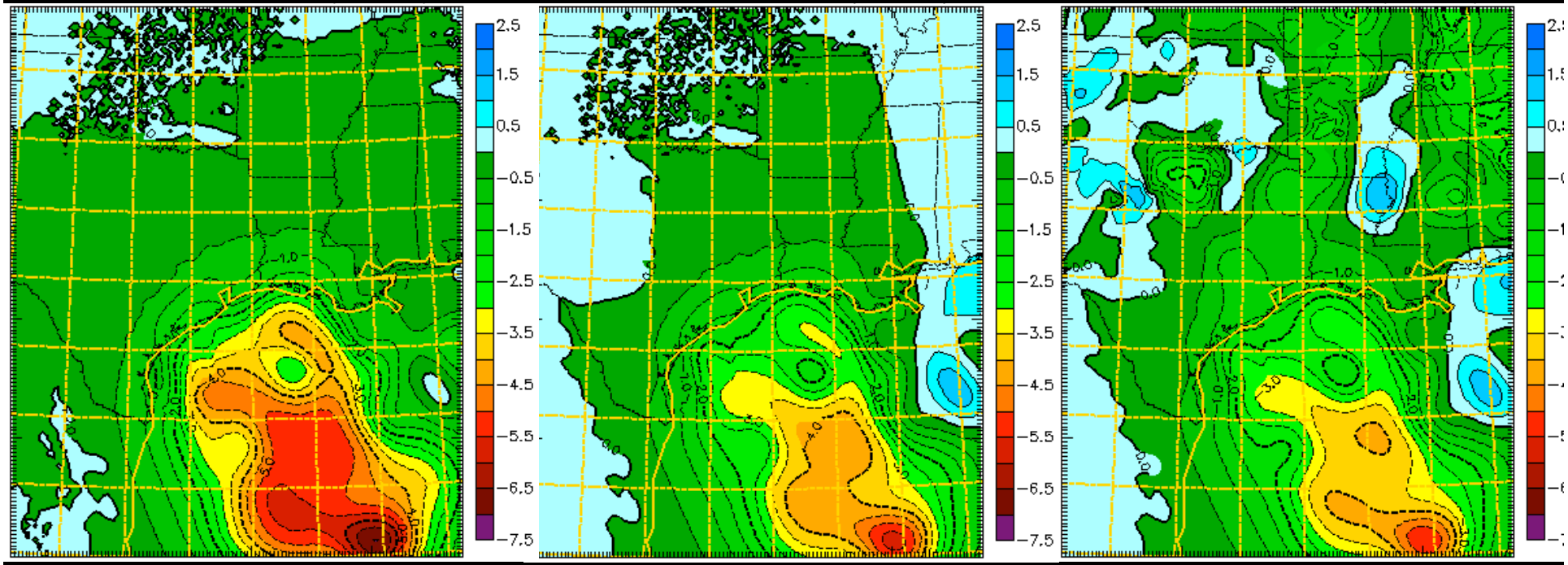
28V4.0 BESO
Bias Removed
Bkgd Smoothed

850 mb Specific Humidity Difference Fields



(28V4.0 N-CTRL) (28V4.0 BE-CTRL) (28V4.0 BESO-CTRL)

Surface Specific Humidity Difference Fields



(28V4.0 N – CTRL)

(28V4.0 BE – CTRL)

(28V4.0 BESO – CTRL)

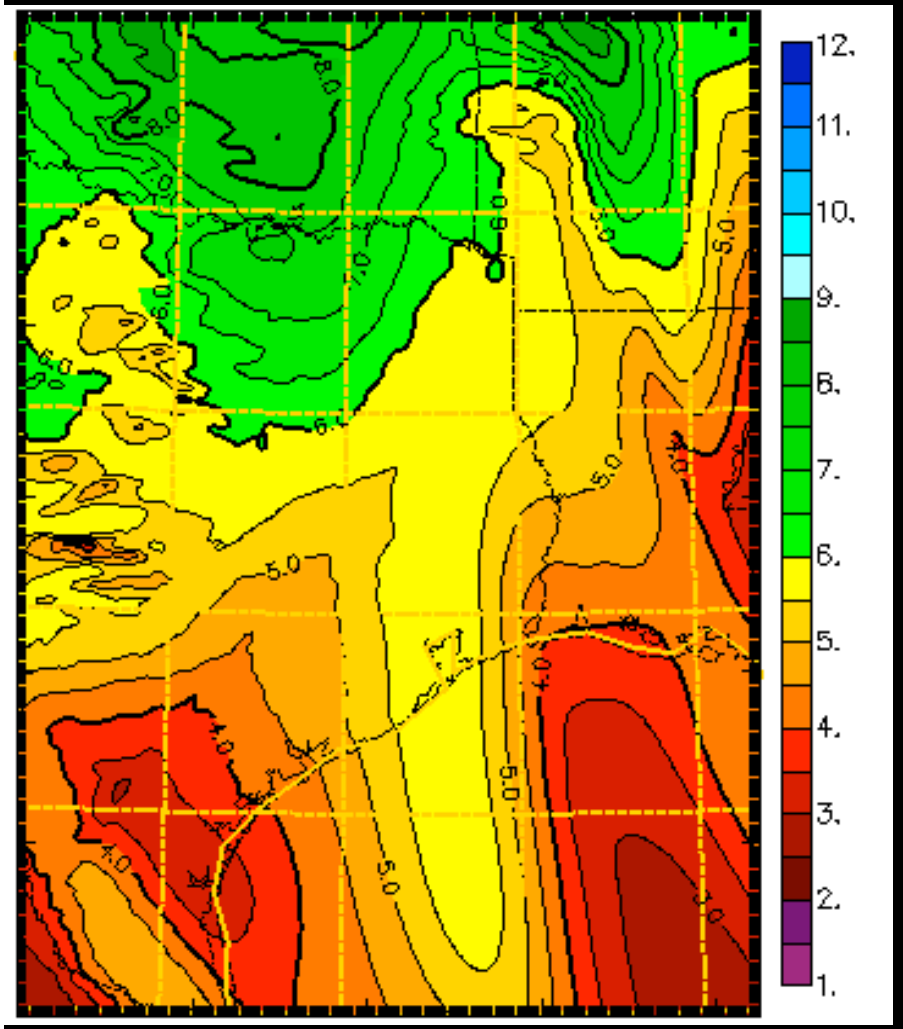
Summary of ADAS Analyses

- Increase in moisture at 850 mb
- Decrease in moisture at the surface
- Greatest increase at 850 mb when bias correction is applied

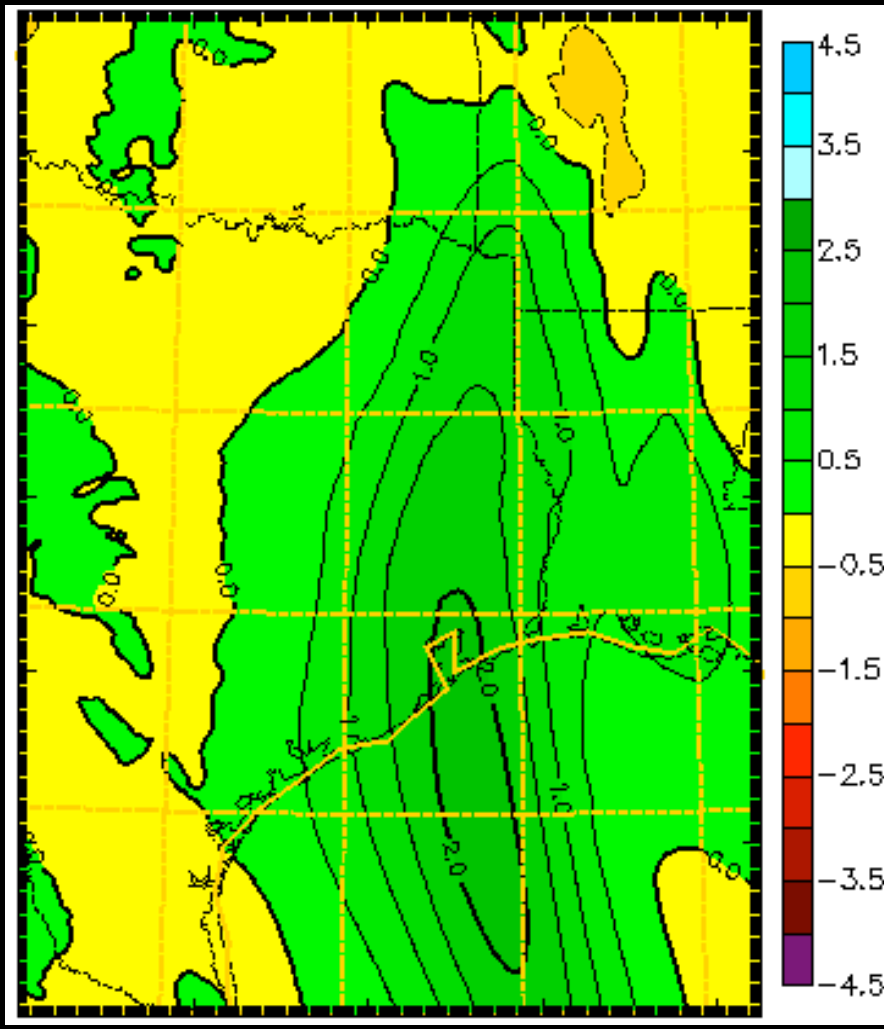
ARPS Forecasts

- Use 28V4.0 BESO and CTRL to produce two separate forecasts
- Model initially run at 12 km
- Use 12 km run as background and boundary conditions for storm-resolving 3 km grid forecast

12-hour Forecast Specific Humidity
850 mb

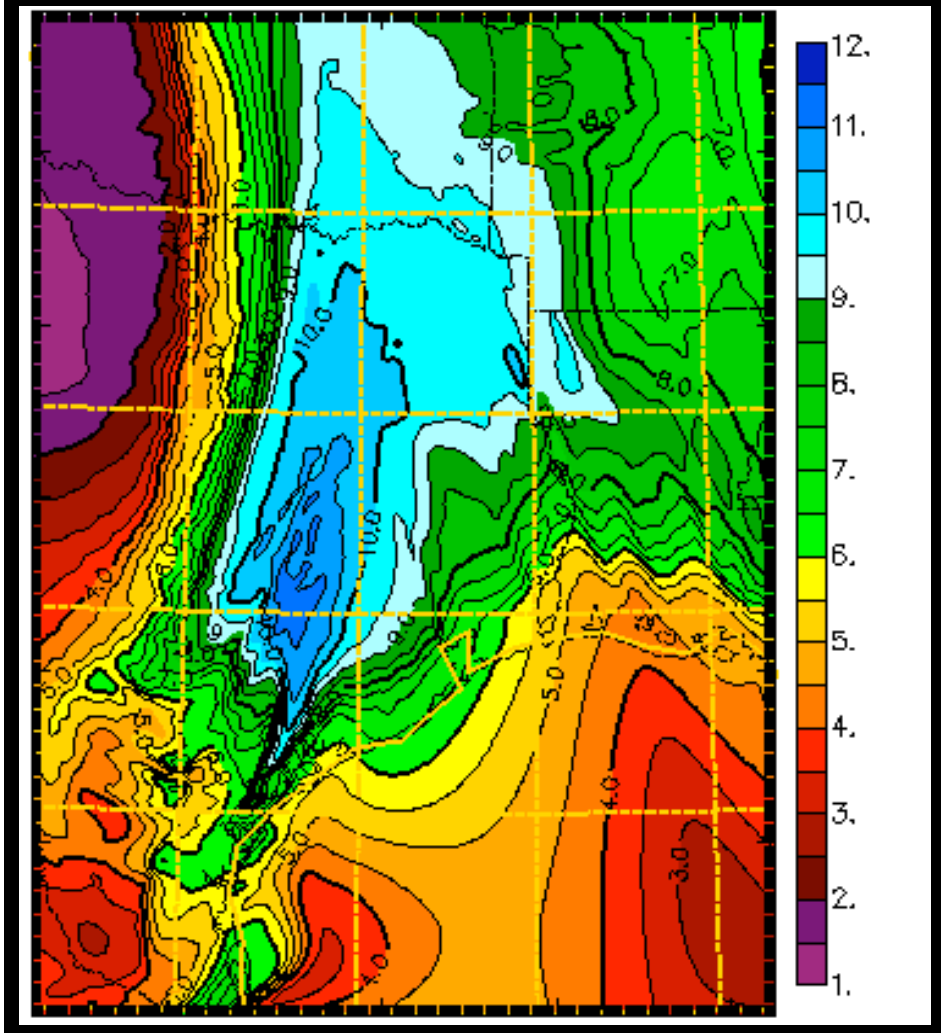


Forecast

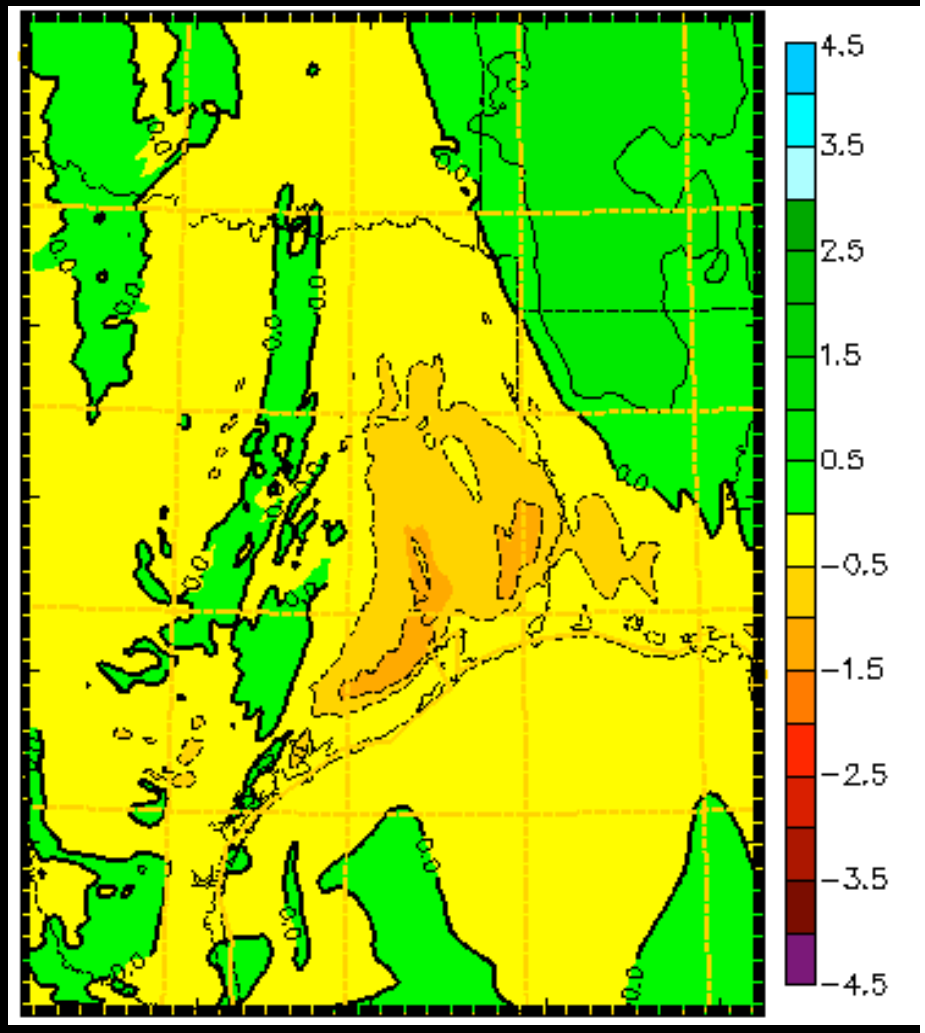


Difference Field
28V4.0 BESO - CTRL

24-hour Forecast Specific Humidity
850 mb

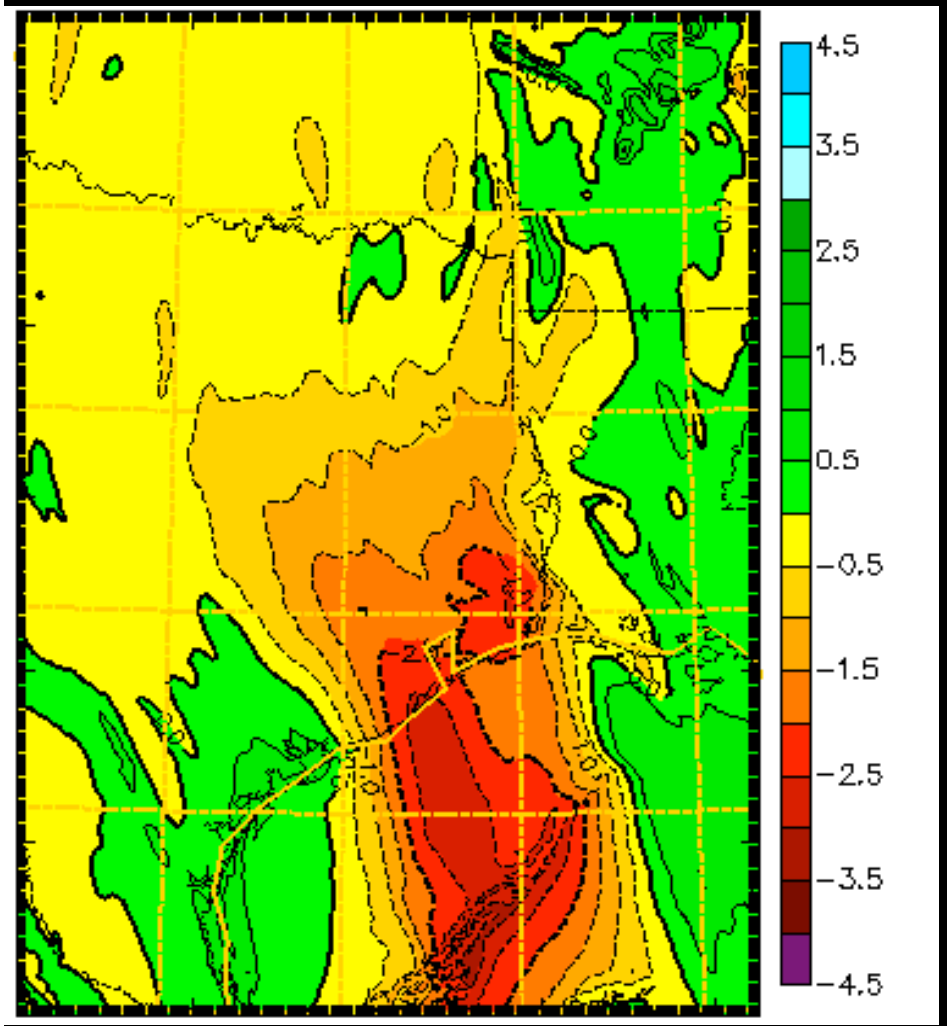


Forecast

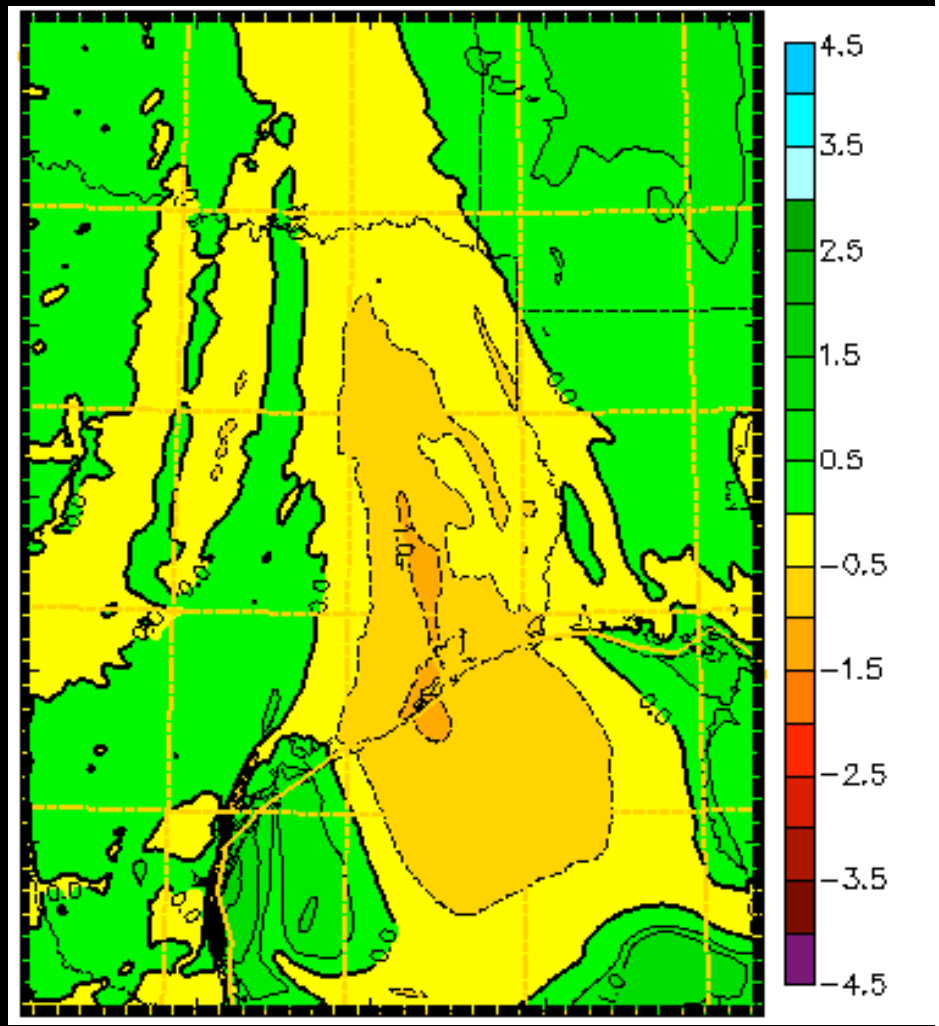


Difference Field
28V4.0 BESO - CTRL

Forecast Differences
Surface Specific Humidity

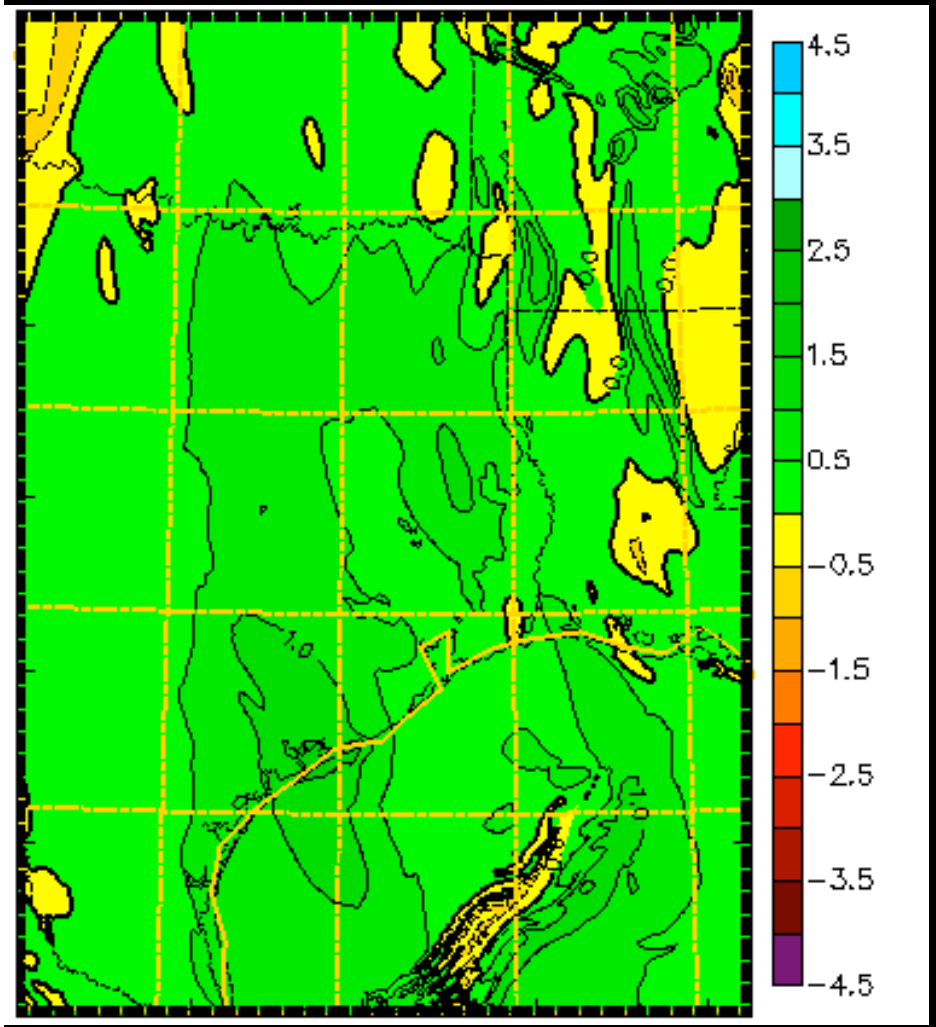


12-hour

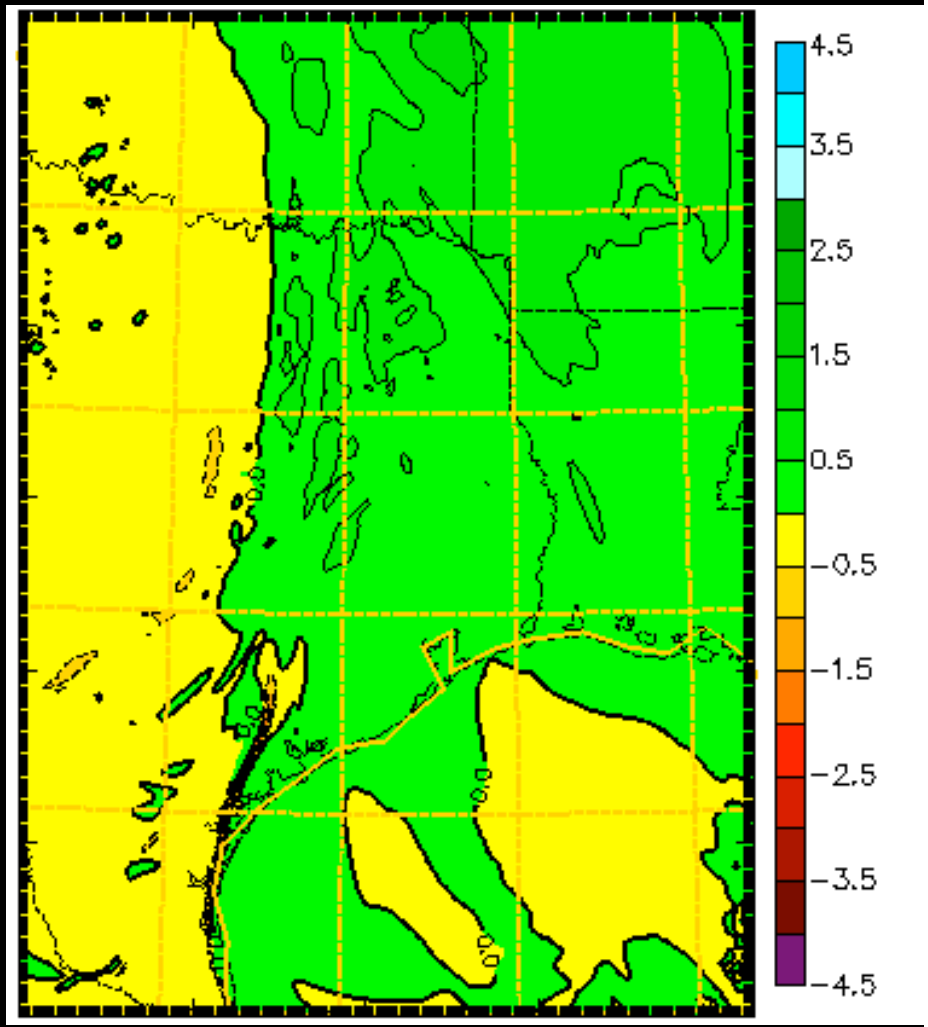


24-hour

Surface Forecast Specific Humidity Differences – No AIRS data at surface and 925 mb

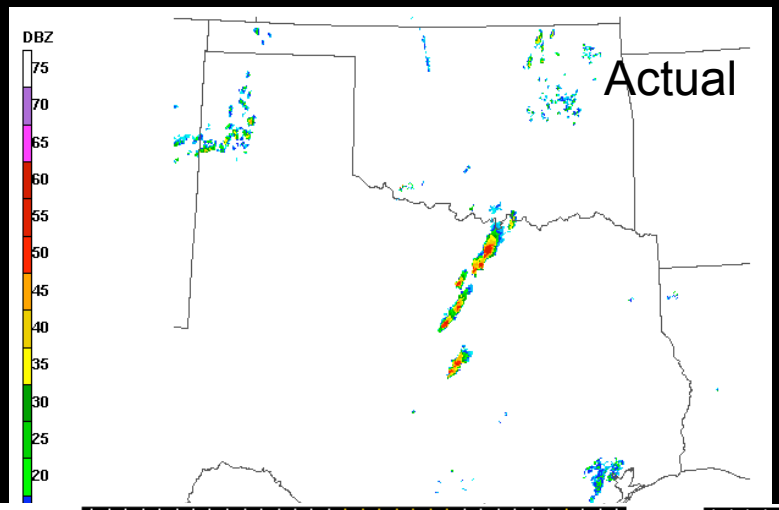


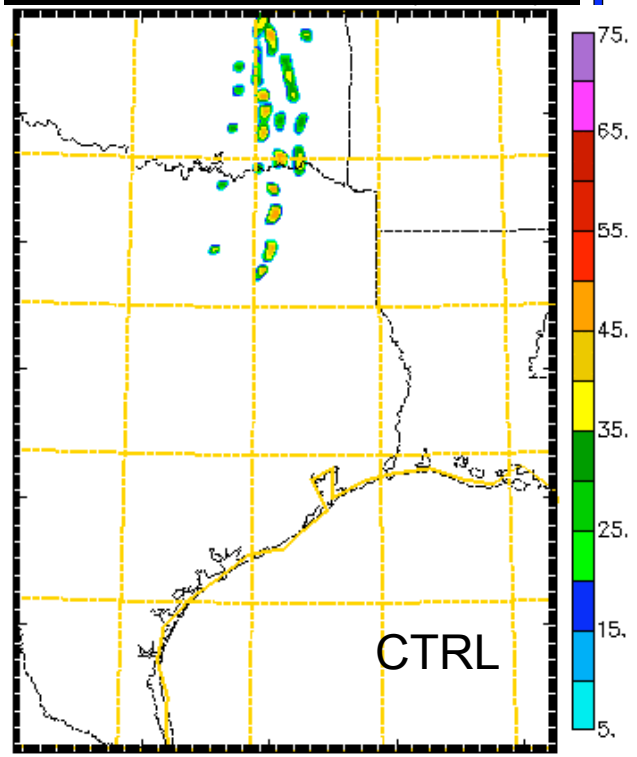
12-hour

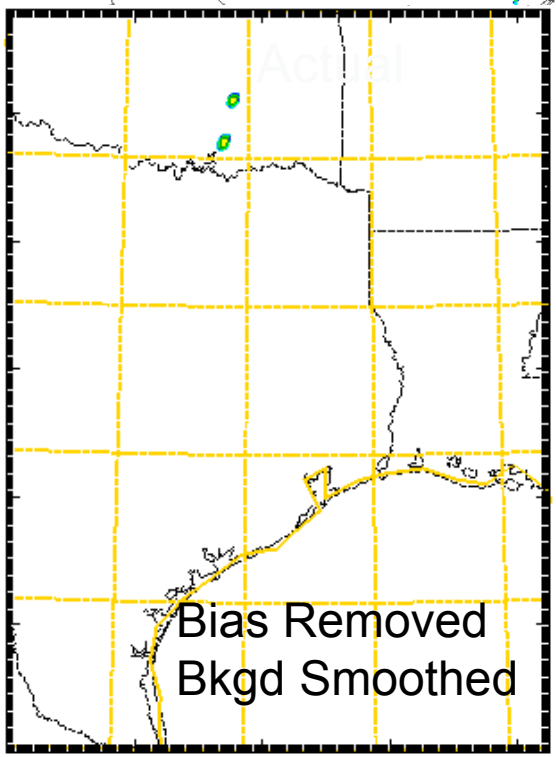


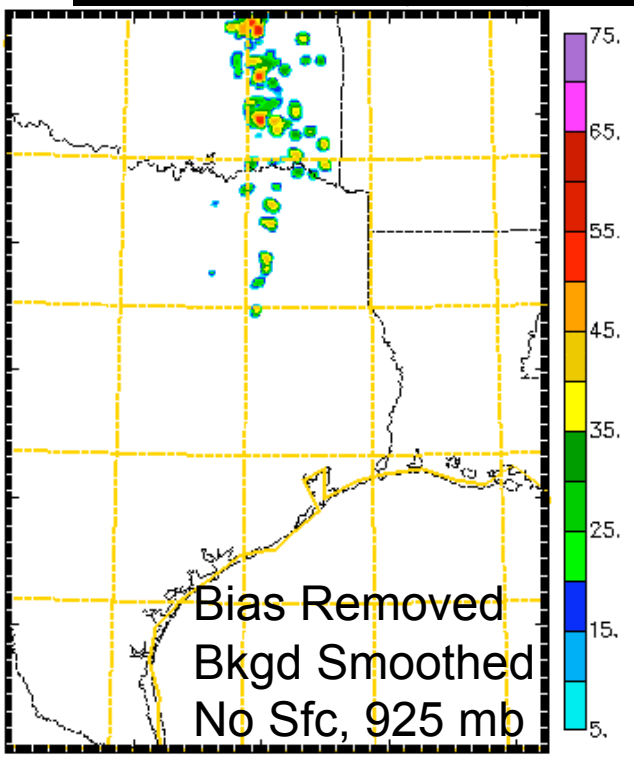
24-hour

Reflectivity 2200 UTC 10 April 2005

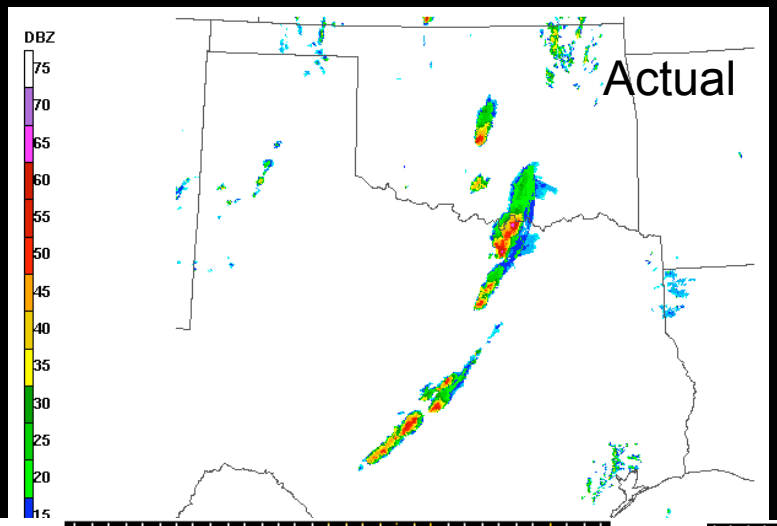


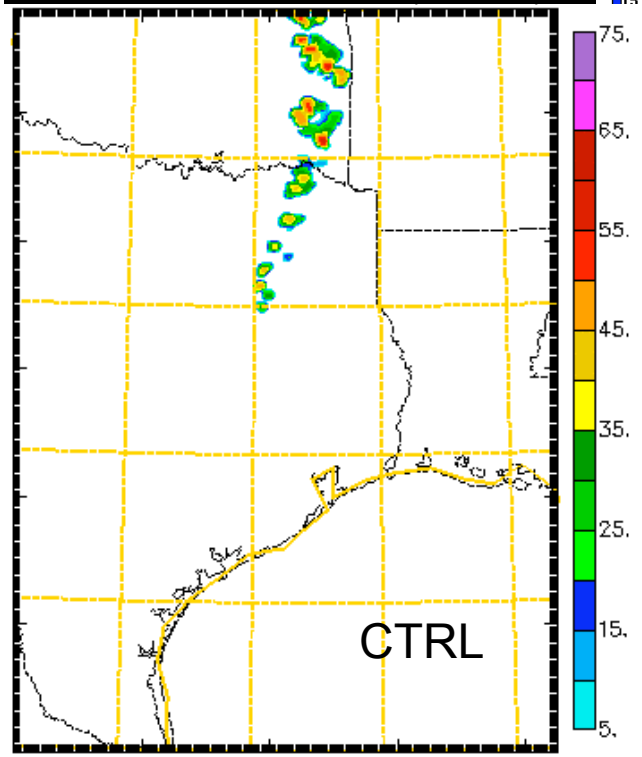


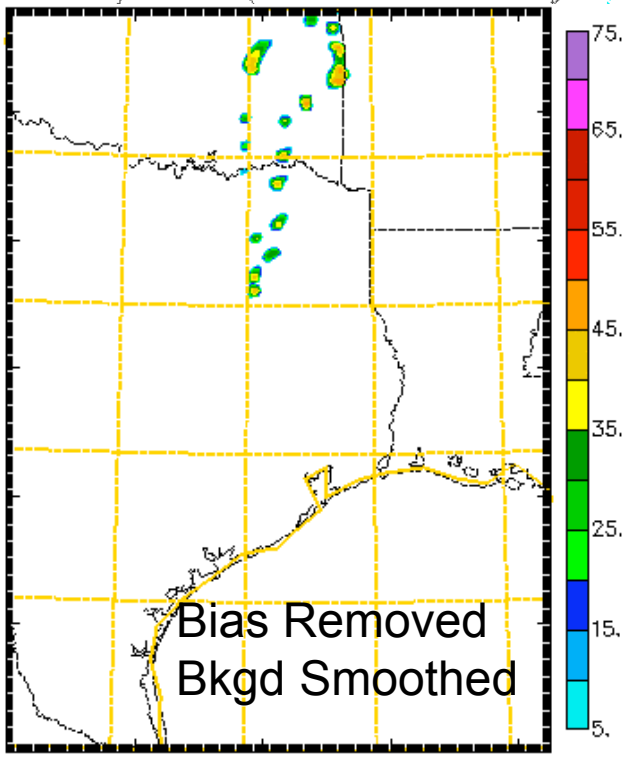


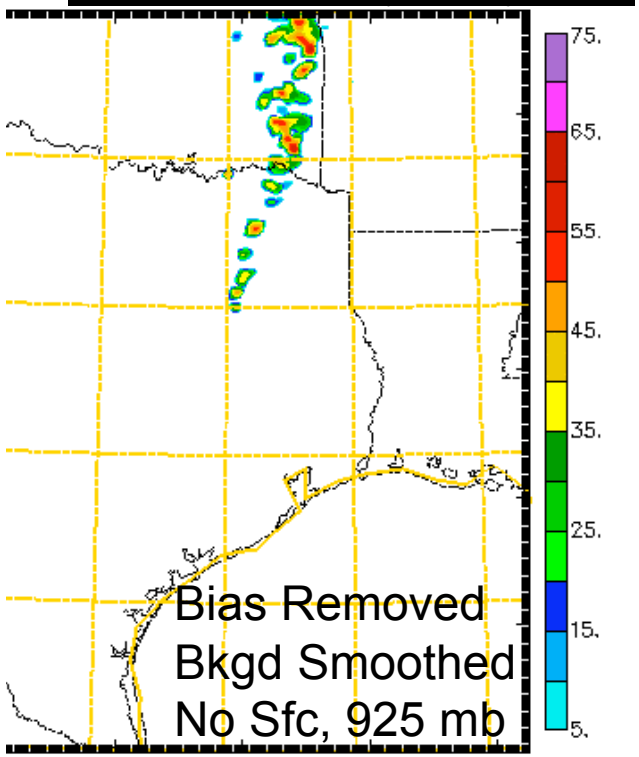


Reflectivity 0000 UTC 11 April 2005



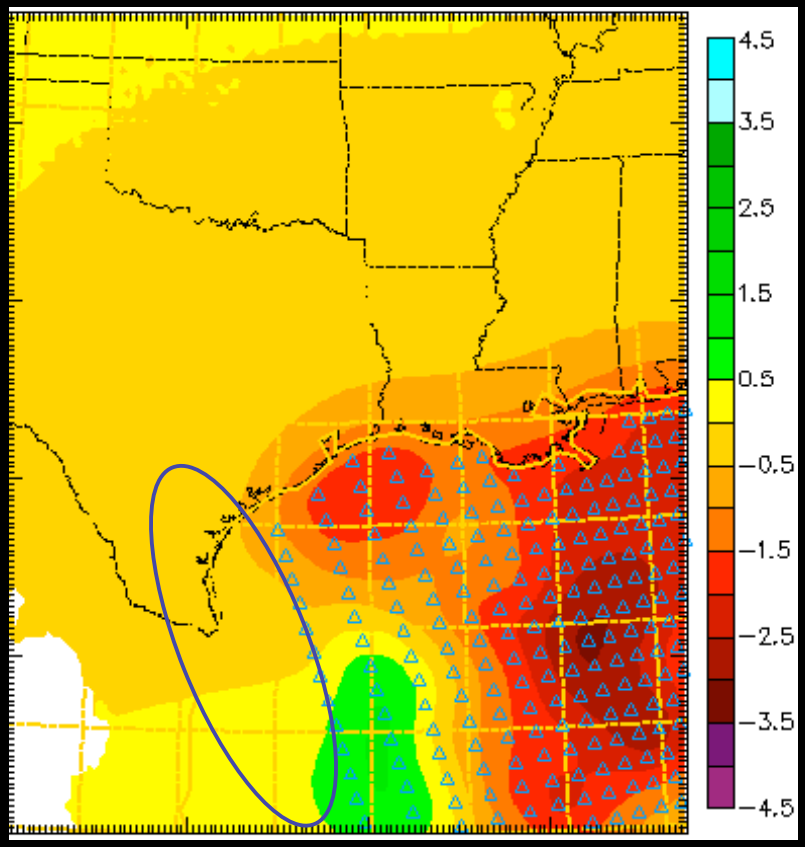






Summary and Conclusions

- Possible reasons impact not stronger:
  - Significant increase in moisture at 850 mb, but decrease in moisture at surface
  - Aqua overpass may have missed deepest of modifying air mass as it did not cover extreme western portion of Gulf on this pass



Future Work

- Verify against surface data
  Exclude surface and buoy data from analysis
- Compare Filter Response to Individual Band Weight Functions
- Explore means to identify when 925-Sfc data may be valid
- Use SST data in combination
  Earlier overpass to allow for BL mixing?
- Study additional cases